Vitamin A in the Horse

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Comparatively little work has been done on the metabolism of vitamin A in the horse. The diet of this animal, although adequate in carotene in farms, may be poor in this respect under urban conditions. It is perhaps surprising therefore that so many horses should appear well and suffer little from disabilities while subsisting on diets low in carotene. There is ample evidence, however, that severe deficiency eventually causes illness. Klemola (1933) found changes in the hoofs of army horses on a ration of oats and hay. Rapid improvements were effected by grazing, or by administering A.I.V. silage (Virtanen, 1933) and cod-liver oil. Vitamin A deficiency in army horses on a ration of straw and hay was also reported by Chatelain (1933) and later by Kesler & Callender (1939). Mitchell (1936) considered that, while definite proof of deficiency in the horse was lacking, some of the commoner diseases, such as rheumatism and the high percentage of abortions in the mare, might be due to vitamin A deficiency. Edwards (1937–8) supported this hypothesis. Skackov (1940), on the other hand, found that neither carrots nor cod-liver oil had any effect on abortions in mares, while others denied that joint lesions were due to vitamin A deficiency (Hart, Goss & Guilbert, 1943). In chemical estimations of vitamin A in horse's liver Linton (quoted by Mitchell, 1936) found little or no vitamin, although Jensen & With (1939) found about 500 i.u./g. Cruickshank (1945) found no carotene in the hay etc. on which pit ponies in a certain mine were supposed to subsist, although they were healthy in appearance and worked hard in the dark. In the absence of some crucial test, however, there is no real proof that they were not night blind.

Experimental vitamin A deficiency has been produced in horses by Guilbert, Howell & Hart (1940). They observed night blindness, roughness of the skin and other symptoms of avitaminosis, but no keratinization of the cornea was seen. The untreated animals eventually died. Andersen & Hart (1943) found that one horse on vitamin A-free diet developed night blindness in 502 days, and when it was killed after another 152 days no vitamin A was found in the liver. A control animal at the same time had 1173 i.u./g. of liver.

EXPERIMENTAL

In the present study, the vitamin A content of the serum and liver of horses has been investigated. Serum was collected from 7 horses belonging to the Institute of Animal Pathology, University of Cambridge. These animals had been kept on a diet of chaff, bran, oats and hay, and had received no green stuff for over 12 months. They appeared normal, healthy, lively and smooth coated. In the eyes there was no noticeable abnormality such as excessive lachrymation or discharges. Other samples of serum and of liver were collected from farm horses, 2–10 years old, at a knacker's yard. These animals had been killed not on account of disease, but because they were more valuable as carcasses than alive. They had been in normal health, and had been passed by qualified veterinary surgeons as fit for human consumption. Most of these horses had probably received considerable amounts of carotenoids by grazing. Serum vitamin A was estimated by the method of Yudkin (1941). Liver assays were made by the method of Davies (1933) with modifications introduced by Moore (1937). Values for serum vitamin A have been corrected for the presence of carotenoids. The small proportion of carotenoids in the liver has been neglected in calculating the vitamin A reserves. The results are given in Table 1.

Table 1. *Vitamin A, carotenoids, and bilirubin in the serum and liver of the horse*

	Serum			
No. of horse	Total carotenoid (i.u./100 ml.)	Vitamin A (i.u./100 ml.)	Bilirubin (mg./100 ml.)	Liver Vitamin A (i.u./g.)
1	12	32	1·0	—
2	25	7	1·6	—
3	14	27	1·4	—
4	14	28	1·3	—
5	8	31	2·1	—
6	6	17	2·2	—
7	6	32	1·2	—
8	—	—	—	1200
9	48	10	3·5	630
10	95	38	2·6	540
11	6	20	2·6	630
12	48	32	4·9	48
13	8	49	3·7	78
14	42	52	4·4	430
15	75	52	7·4	2000
16	0	50	3·3	171
17	390	6	3·9	1500
18	35	23	4·4	735
19	12	29	2·1	189
20	36	23	3·3	720
21	8	44	2·8	610
22	0	31	2·5	32
23	6	30	2·7	780
24	60	37	4·3	480
25	34	24	4·5	375
26	146	15	3·7	400
27	288	9	1·3	375
28	220	15	4·4	400
29	442	22	5·0	1500
30	34	40	1·7	—
Means	73	28	3·1	628

It is evident that the vitamin A content of the serum of horses is usually of a low order. Clearly even when the animals have a large intake of carotenoids, as evidenced by a high vitamin A reserve in the liver, or by a high value for serum carotenoids, the vitamin A content of the serum remains low. Thus, although horse 15 had 2000 i.u. of vitamin A/g. of liver, and no. 29 had 1500 i.u. of vitamin A/g. of liver and 442 'i.u.' of carotenoids/100 ml. of serum, the highest serum vitamin A for any horse was only 52 i.u./100 ml. Too much reliance, however, should not be placed in the very low values found in some horses having high serum carotenoids, in view of the uncertainty of the correction factor for carotenoids in the $SbCl_3$ reaction. Little correlation can be traced between either the plasma carotenoids and vitamin A, or between the vitamin A contents of the plasma and liver.

A surprising finding is that the serum of all the horses, without exception, contained relatively large amounts of bilirubin (Table 1) as estimated by the modified method of the author (Rudra, 1945). It is interesting to note that high vitamin A reserves in the liver generally synchronized with a high bilirubin content in the serum. The horse with the highest liver vitamin A (2000 i.u./g.) had also the highest serum bilirubin content (7·4 mg./100 ml.). It may also be significant that the farm horses, which presumably received much carotene in their diet, had also high bilirubin contents in their serum. No bilirubin could be detected in normal or vitamin A deficient calf serum, normal sheep serum or donkey serum. Royer, Chiaravalle & Aramburu (1941) also found that the blood plasma of the horse contained 0·5–3·0 mg. of bilirubin/100 ml., while a similar conclusion has recently been reached by Ramsay (1945). In the absence of evidence to the contrary we should regard a high serum bilirubin as a normal occurrence in this animal. The frequent presence of large amounts of bilirubin, in the serum of farm horses, and the lower range of values in horses living on a diet almost free from carotene, suggests some curious and novel relationships in the vitamin A metabolism in the horse, but no satisfactory explanation can yet be suggested.

SUMMARY

1. The vitamin A content of the serum of English horses varied from 6 to 52 i.u./100 ml. with a mean of 28 i.u. The vitamin A content of liver varied from 32 to 2000 i.u./g. with a mean of 628.

2. Horse serum normally contains bilirubin. The amounts found varied from 1·0 to 7·4 mg./100 ml., with a mean value of 3·1 mg.

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The Mineral Constituents of Bone

3. THE EFFECT OF PROLONGED PARATHORMONE INJECTIONS ON THE COMPOSITION OF THE BONES OF PUPPIES WITH VARYING CALCIUM INTAKES

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'Osteitis fibrosa cystica' has frequently been correlated with hyperparathyroidism in human beings (Hunter & Turnbull, 1931–2). Many workers have attempted to produce the condition in animals by a combination of repeated injections of parathyroid extract and other treatment such as diet. Bauer, Aub & Albright (1929) used cats, rats and rabbits, Bodansky, Blair & Jaffe (1929–30) guinea-pigs, Selye (1932) rats, Greenwald & Gross (1926), Jaffe & Bodansky (1930), Johnson (1932) and others used dogs. Herbivora needed very large doses of the hormone to produce a measurable effect on blood